FAA-E-2648
February 13,1976

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

POWER CONDITIONING SYSTEMS INSTALLED IN RML's

1. SCOPE AND CLASSIFICATION

1.1 Scope. - This engineering specification sets forth the requirements for design, fabrication, factory testing, installation and field validation of a solid state non-rotary power conditioning system (PCS) which will be installed and operated in the Federal Aviation Administration radar microwave link facilities. The PCS shall supply continuous power of precise quality to the critical load.

1.2 Classification. - The PCS rating shall be Class 3 or 5 as required by the contract, with a single phase output voltage of 120 volts. The Class 3 shall be a 3 KVA to be installed in single RML's and the Class 5 shall be a 5 KVA to be installed in dual and triple RML's as shown on typical installation drawings attached as part of this specification.

2. APPLICABLE DOCUMENTS

2.1 FAA Documents. - The following specifications and standards shall form a part of this specification and shall be the latest issue in effect on the date of issuance of Request for Proposals or invitations for bids.

2.1.1 FAA Specifications. -

FAA-G-1210	Provisioning Technical Documentation
FAA-C-1217	Electrical Work, Interior

FAA-G-1375	Spare Parts Peculiar for Electronic, Electrical and Mechanical Equipment. FAA Parts Peculiar Replacement Table
FAA-D-2494/1&2	Instruction Book Manuscript Technical

2.1.2 FAA Standards. -

FAA-STD-002	Engineering Drawing Standards
FAA-STD-010	Graphic Symbols for Logic Diagrams
FAA-STD-013a	Quality Control Program Requirements

2.1.3 FAA Orders. -

4630.2	Standard Allowance of Supplies & Working Equipment
6200.4	Test Equipment Management Handbook

2.1.4 FAA Drawings. -

Dwg. No.	Description
D-5207	RML Repeater (single, dual & triple) & Terminal Facilities Typical Site Layout
D-5457-1	Microwave Link Bldg, Dual Repeater Plan & Elevations
D-5457-2	Microwave Link Bldg, Dual Repeater Foundation and Wall Section Details
D-5457-3	Microwave Link Bldg, Dual Repeater Electrical Detail
D-5594-1	Microwave Link Bldg, Triple Repeater Plan and Elevations
D-5594-3	Microwave Link Bldg, Triple Repeater Foundation and Floor Plans
D-5594-5	Microwave Link Bldg, Triple Repeater Electrical Details
D-5594-6	Microwave Link Bldg, Triple Repeater Electrical Details

D-5594-7	Microwave Link Bldg, Triple Engine Generator Installation

2.2 Other Documents.-

2.2.1 National Electrical Manufacturers Association Standards (NEMA).-

AB-1	Molded Case Circuit Breakers
WC-5	Insulated Wire
CP-1	Shunt Capacitors
ICS-70	Industrial Control
PB-1	Electrical Panel Distribution

2.2.2 National Fire Protection Association Publications.-

National Electrical Code

National Safety Code

2.2.3 Other Standards.-

Guide and Data Book American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

Code 210 Air Moving and Conditioning Association, Inc.

2.2.4 Other Specifications.-

W-B-134 Battery Storage (Lead Acid Industrial Floating Service)

2.3 Precedence.- The contract shall take precedence when conflict exists between the requirements of the contract and this specification. This specification shall take precedence over documentation referred to herein.

Copies of this specification and other FAA publications cited above may be obtained from the Contracting Officer in the Federal Aviation Administration office issuing the invitation for bids or request for proposals. Requests should fully identify the material desired, and should cite the invitation for bids, request for proposals, or the contract involved or other use to be made of the requested material.

Information on obtaining copies of NEMA standards may be obtained from National Electrical Manufacturers' Association, 155 East 49th Street, New York, New York 10017.

Information on obtaining copies of National Fire Protection Association Standards may be obtained from National Fire Protection Association, 60 Batterymarch Street, Boston, Massachusetts 02110.

Information on obtaining copies of the American Society of Heating, Refrigerating and Air-Conditioning Engineers Guide and Data Book may be obtained from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 345 East 47th Street, New York, New York 10017.

Information on obtaining copies of the Air Moving and Conditioning Association, Inc., Code 210, may be obtained from the Air Moving and Conditioning Association, Inc., 30 W. University Drive, Arlington Heights, Illinois 60004.

3. REQUIREMENTS

3.1 General.-

3.1.1 Description of System.- The PCS specified herein shall be installed at FAA Radar Microwave Link (RML) facilities as delineated in the contract. A typical system single line block diagram is shown on Figure 1. The system shall include all mechanical and electrical devices that shall automatically provide a continuous supply of precise electrical power to the critical load feeders emanating from a distribution panel.

3.1.2 Operation.- Normally, electrical energy from the a.c. power source, either commercial power or standby engine generators, shall be converted into d.c. power. The d.c. power shall be fed into inverters and batteries. The a.c. output of the inverter shall be connected to the critical load through a static transfer switch. In the event of deterioration or failure of commercial power, the system shall continue to provide power to the critical loads for a specified time by utilizing the storage batteries to supply the inverter. When commercial power service is restored or emergency generators provide an alternate service, the system shall automatically revert to the incoming a.c. supply or generator. A solid state transfer switch shall transfer the load to the bypass line on failure of the PCS equipment, failure of the transfer switch or heavy fault currents occur in the distribution system. Within the range of a.c. input conditions, no power shall be withdrawn from the storage batteries. Manual startup shall be accomplished by closing of the a.c. supply breaker. A second manual action shall initiate the operation of automatically connecting the PCS equipment to the output load. The PCS equipment shall be shut down by the operation of a single stop button or by operation of the supply breaker, or by automatic bypass.

3.1.3 Investigation.- The contractor shall investigate and satisfy himself as to the conditions affecting the work at each site including, but not restricted to, those bearing upon transportation, disposal, handling and storage of materials, availability of labor, roads and uncertainties of weather, conditions at the sites, the character of equipment and facilities needed preliminary to and during execution of the work, as well as from information presented by the drawings and specifications made a part of this contract.

A visit to each site shall be arranged through the regional office and be completed ninety (90) days in advance of any construction to determine the actual physical conditions at the site. Any significant discrepancies found from those shown on Figure 3 shall be reported to the Contracting Officer. Upon completion of the site survey a detailed schedule and work plan of the installation shall be presented to the FAA Contracting Officer and Regional Office where the installation is to be performed. If the Contractor fails to conduct such site investigations, he shall be responsible for the accomplishment of all necessary remedial work as may be required for the complete accomplishment of the PCS installation without delay and without additional cost to the Government.

3.1.4 Design Configuration and Documentation.- The Contractor shall provide complete drawings of his PCS equipment, as required by the contract, including manufacturing and shop drawings, wiring diagrams, wire and parts lists and circuit diagrams. Each logic card shall have a separate schematic diagram and there shall be a logic block diagram showing the interrelationship of all cards and inter-card wiring.

The Contractor shall also provide an instruction book in accordance with FAA-D-2494, as required by the contract, which consolidates all design, installation, test and maintenance characteristics, and shall indicate signal characteristics and limits of power requirements. The data shall include all major intra-system as well as all external system interfaces and protective devices, including trip units on circuit breakers and installation details of remote monitors.

3.1.5 Preliminary.- A preliminary design data submission shall be made, as required by the contract, to reflect the Contractor's approach to the development of the system to meet the specification. The design data specified shall include all elements for the equipment to be produced or procured by the Contractor under the terms of the contract, together with all interfaces with other equipment.

3.1.5.1 Functional Description.- The Design Data shall include a detailed functional description as necessary to describe the proposed equipments, their use in the system, their electrical characteristics, theory of operation and relationships.

3.1.6 Block Diagrams.- A complete set of Equipment Block Diagrams shall be provided by the Contractor, as required by the contract. These diagrams shall show

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printed circuit cards from vibrating out of their sockets and being installed improperly. Control connections to removable subassemblies shall be by flexible cable and multi-pin connectors. The flexible control cable shall be of sufficient length to permit removing the subassembly and shall be supported in a manner to provide positive mechanical protection and to prevent interference with the removal of adjacent subassemblies. Identical subassemblies shall be interchangeable, and identical parts shall be interchangeable with those in other subassemblies.

Each removable subassembly shall contain the maximum practical amount of parts functionally associated with its main components. Within the logic subassembly of the PCS equipment, separate functions shall be on individual printed circuit cards to allow circuit card replacement to effect repair.

3.2.4 Size.- The equipment shall be floor mounted and the maximum dimensions shall be 78 inches high, 36 inches wide and 30 inches deep, excluding battery rack and batteries, distribution panel and maintenance lockout switch. The maximum floor weight shall be 1.5 lbs. per sq. in., over the area to be covered by the equipment.

3.2.5 Semi-Conductor Devices.- Semi-conductor devices shall be hermetically sealed and are required. Electron tubes shall not be used.

3.2.5.1 Power Thyristors and Diodes.- Power thyristors and diodes shall be purchased to source control drawings or specifications, or both. The Contractor's procurement documents shall be provided, as required in the contract, to the Government and shall include tests and parameters essential to proper operation in the Contractor designed circuit.

3.2.5.2 Single Source Availability.- No semi-conductor device shall be used unless that device or an equivalent device is available from more than one manufacturer.

3.2.6 Parts Control.- Standard parts shall be used. The Contractor shall establish a parts control procedure that shall, to the maximum extent possible, assure utilization of standard parts. Non-standard parts may be utilized when approved by the Government. The Contractor shall submit requests for non-standard parts. The request shall contain appropriate drawings, specifications and failure rate of the part in equivalent service. The procedure shall also assure proper application and derating to fulfill the reliability and life requirements specified herein.

3.2.7 Critical Load Panel.- The Panel "C", shown on Figure 1, shall be NEMA Type 12, with a minimum of 8 circuits, 100 amperes, 120/240 volts, surface mounted.

3.2.8 Control Devices.- Control, transfer switches and pushbuttons shall be the heavy duty type conforming to the requirements of NEMA.

3.2.9 Wire and Cable.- All insulated wire used in the equipment or installation shall meet the requirements of NEMA.

3.2.10 Wiring Methods.-

3.2.10.1 All wiring shall be in accordance with FAA-C-1217 and the National Electrical Code. FAA-C-1217 shall take precedence when a conflict exists.

3.2.10.2 Ampacity.- Conductor size shall be based on the National Electrical Code.

3.2.10.3 Interconnections.- Terminal blocks shall be accessible for testing and maintenance. Wire wrap terminals shall not be used. Terminal blocks shall be of the double terminal type. Not more than two wires shall be attached to any terminal. This applies to component terminals as well as terminal blocks. All terminal blocks shall be numbered and identified in the equipment.

3.2.10.4 Wire Identification.- All insulated wire used in circuit connections except short point-to-point jumpers which are not laced into cables and which are easily followed by eye between interconnected points, shall be positively identified by a number which is unique to the assembly, or subassembly in which it is used. The number shall be secured to each end of the wire with a durable nonmetallic wire marker. Full reference designations of all terminals shall be shown on the wire connection diagrams, or a wire list shall be provided which identifies the wire number and the full reference designation of the terminals to which each end of the wire is connected.

3.2.10.5 Terminations.- Captive ring-tongue lugs shall be used for all connections to screw terminals. On terminal strips which have barriers between each connection and use screws to secure the lugs, not more than two lugs shall be attached to each screw terminal and not more than three lugs per stud terminal. All lugs shall be fanned out so as not to deform or bend other lugs attached to the same or adjacent studs and so that all numerical designations on each wire are readily visible.

3.2.11 Torque Requirements.- All screw connections of electrical conductors and components shall be tightened in accordance with a torque table developed by the Contractor. The torque table shall be submitted as a part of the documentation required by paragraph 3.1.4 and 3.1.7.

3.2.12 Grounding and Bonding.-

3.2.12.1 Grounding and Bonding Systems.- The grounding system shall be installed in accordance with the National Electrical Code.

3.2.12.2 Grounded Conductor.- The neutral of each power transformer shall be connected to the grounded conductor by an insulated conductor.

3.2.12.3 Equipment Grounding Conductor.- Frames, chassis and other noncurrent-carrying metal parts of equipment, enclosures, or raceways, with the PCS, except the battery rack, shall be interconnected by a copper wire or bus bar which in turn shall be connected to the equipment grounding conductor per the National Electrical Code. The equipment grounding conductor shall not be connected to the 'Grounded Conductor' within the PCS equipment and shall be routed in the same conduit or raceway, as the grounded conductor and the circuit conductors. The equipment grounding conductor, equipment frame and/or chassis shall not be used as a common for signals, power or any other function.

3.2.12.4 Signal Common.- Shields of signal circuits and signal return or common shall be connected to a common bus isolated from frame, chassis, or other noncurrent-carrying metal part and shall be connected by an insulated conductor. The returns of power supplies, the common plane of logic boards and the d.c. return for all printed circuit boards shall be isolated from the grounding conductor, frames, or chassis. Any common connections required shall be through the isolated signal common bus.

3.3 Personnel Safety.-

3.3.1 Barriers and Guards.- Drawer fronts and removable panels shall be considered as barriers. Each drawer front or removable panel containing voltages above 150 volts shall be provided with a sign warning of high voltage. Voltages which may be contacted by maintenance personnel shall be covered by protective panels, barriers, or guards.

3.3.2 Power Drawers.- All power drawers or rollout carts whose removal causes the separation of contacts in a power circuit shall be provided with a sign marked "DO NOT OPEN WHEN EQUIPMENT IS ENERGIZED." Markings shall have white letters (a minimum of 1/2" high) on a bright red background and placed as close as possible to the point of danger.

3.3.3 Capacitor Discharge.- All capacitors shall discharge to a potential of 50 volts or less within one minute after disconnection of the power supply.

3.4 Controls and Instruments.-

3.4.1 Operational Status Panel.- An operational status panel shall be part of the PCS equipment, shall include all devices required for control, instrumentation and indication and shall indicate at least the following parameters:

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limiting devices shall be used to protect against failure of solid state devices. An internal failure in the PCS equipment shall cause the equipment to shut down before the failure causes additional damage to the system. The PCS equipment shall be disconnected and isolated from the remainder of the system by means of a solid state transfer switch. The speed of transfer shall be such that the system output remains within the limits as shown on Figure 2.

3.5.2 Rating.- The continuous output capacity of each PCS shall be as specified in paragraph 3.8 at the power factor, a.c. input conditions and environmental conditions specified in paragraph 3.6.2 and 3.6.6. Under the same a.c. input conditions the module shall be capable of supplying, without damage to the equipment, to a distribution overload or equipment inrush, an rms overcurrent of at least 125% of rated rms current. Upon application of an external fault or overload in excess of 125% of rated current, the system shall transfer to bypass.

3.5.3 Battery Charging.- The PCS equipment shall be capable of supplying the specified load and shall be able to recharge the batteries within 8 hours to 95% of full charge after discharge to 1.75 volts per cell. The rectifier shall be equipped with an adjustable battery-charging current limit, and shall be independent of any current limit the Contractor may supply for limiting total rectifier load. Battery charging rate shall not exceed that recommended by the battery manufacturer. There shall be no battery drain within the tolerances specified for a.c. input to the PCS, and from no load to full load.

3.5.4 Noise Level Limits.- The noise level of the equipment under test conditions in a quiet room shall be not more than 75 db, "A" scale, as defined by OSHA in CFR, Title 29, Chapter XVII, Part 1910.95.

3.5.5 Electromagnetic Interference.- Radiated or conducted electromagnetic interference (EMI) effects shall be eliminated by shielding, trapping, or other appropriate means.

Under design qualification test conditions the PCS shall comply with the requirements of MIL-STD-461A, Table I, Class IIA.

3.6 Ratings of Operational Conditions.-

3.6.1 Input Operational Range.- The PCS equipment shall, within the ranges of 102 volts to 138 volts, or 204 volts to 276 volts, single phase and frequency of 57 to 63 Hz, operate under full load with no reduction of the rated output and no drain on the battery bank.

3.6.2 Normal Test Conditions.- Normal test conditions on the input shall be 120 volts ± 2 volts/240 volts ± 4 volts and 60 Hz +0.5 Hz.

3.6.3 Power Factor.- Lagging reactive input power for the system at normal test conditions shall not exceed 10 percent of the KVA rating when operating at full load and when charging the battery.

3.6.4 Distortion Effect on the Input Power Source.- The total rms current generated at the input service by the PCS and fed back into an a.c. supply system with linear impedance of 0.01 ohm shall not exceed 5% of rms full load current.

3.6.5 Environmental Conditions.- Each system shall be capable of delivering full rated output at the specified environmental conditions.

a. Altitude All equipment shall be suitable for operation up to an elevation of 11,000 ft above mean sea level.

b. Temperature Ambient in Room

Equipment	Minimum Degrees C	Maximum Degrees C
P.C.	0°	$+50^{\circ}$
PCS storage batteries	0°	$+50^{\circ}$

Equipment heating may be used provided thermostat control is incorporated to allow heating only between the contractor's PCS equipment lowest operating temperature and 0° C.

c. Relative humidity 5 percent to 95 percent.

3.6.6 Environmental Test Conditions.- Normal elevation conditions shall be at the elevation of the test location and with the relative humidity existing at the time of tests. Temperature range shall be in accordance with the maxima and minima specified in paragraph 3.6.5.

3.7 Operational Modes.- The PCS shall be capable of being operated automatically and manually by the operation of a transfer switch located in the PCS and in the maintenance mode by operation of a separate switch.

3.7.1 Automatic Bypass and Return.- The PCS shall bypass automatically to the incoming a.c. source whenever the output voltage and frequency tolerances of the PCS are exceeded. The automatic bypass shall be an open circuit transfer and the PCS shall shut down.

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Transient	Tolerances Voltage	Frequency
Step load changes (made instantaneously by operation of a single switch).		
Any load up to ±100% of rating	+8%,-10%	±1/2%
Loss or return of a.c. input	+8%,-10%	±1/2%
Manual and Automatic Transfer	+8%,-10%	±1/2%

The output voltage shall remain within the envelope shown on Figure 2 during transient operating conditions resulting from clearing a distribution system fault, or operation of the transfer switch. The equipment shall operate within envelope limits at all loads within the rating of the equipment whether on a.c. source, the batteries, or in transition from one source to another.

3.8.4 Wave Form.- The total harmonic distortion as measured on the critical load voltage, shall not exceed five percent at all loads from no load to full rated load at all power factors between 0.8 lagging and unity.

3.8.5 Efficiency.- Efficiency shall be the ratio of power output to power input with the battery floating in a fully charged condition. Under all input conditions, the efficiency at full load shall be not less than 0.70.

3.8.6 Frequency.- The output frequency shall be controlled by a self-contained oscillator.

3.8.7 Voltage Control.- The output voltage shall be controlled by a self-contained regulator. Voltage at the output shall be controlled within the limits specified in paragraph 3.8.3 within the range of input conditions.

3.9 Battery Facilities.-

3.9.1 Battery Rack.- The Contractor shall design the equipment to fit within the space intended as shown in the typical installation drawings. Arrangement shall provide the optimum space for personnel safety, operability and maintainability. Clearances shall be equal to, or greater than, those specified in the National Electrical Code. Battery racks shall be furnished to accommodate the complete battery bank for the PCS and engine generator in a manner permitting convenient servicing and arrangement within the space limitations given. The racks also shall be earthquake resistant type and shall be resistant to corrosion or deterioration from battery electrolyte. Space for twenty (20) batteries with 3 cells per battery with a nominal 100 A/H capacity at an 8 hour rate per battery shall be available.

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3.10 Reliability and Maintainability Parameters.-

3.10.1 Reliability and Maintainability.- The PCS shall be designed to be maintained with a minimum of external test equipment and special tools. Test and working equipment, special tools, and hand tools, if required, which do not appear in FAA Order 6200.4 and Order 4630.2 as amended, for the facility type being supplied by the PCS specified herein, shall be provided by the Contractor with each PCS installed. Corrective maintenance shall be effected to the maximum extent possible by replacement of defective assemblies, subassemblies, or items with subsequent repair of the defective units off-line. Contractor shall provide a list of all equipment needed for maintenance 2 months prior to the first article tests and furnish all special items with each hardware delivery.

Requirements for adjustments shall be kept to a minimum. The design shall maximize interchangeability and minimize the need for tuning and/or adjustment. Every attempt shall be made to limit the variety of devices, equipment types, printed circuit boards and assemblies used in the system through design standardization techniques.

3.10.2 Reliability Modeling Task.- The PCS shall be reliability modeled. The Contractor shall identify critical items or paths whose failure will either cause system failure, major performance degradation, marginal operational conditions or departures from the reliability prediction and the reliability model together with system operational demands. Critical elements shall be highlighted and pinpointed with emphasis upon means of sustaining operation via techniques such as redundancy, over-capacity, and other methods in the event of failure. The ability to sustain operation in this manner shall not preclude the incident from being classified as an equipment failure during the tests specified in paragraph 4.

3.10.3 Failure Modes and Effects Analysis Task.- A FMEA shall be performed. This analysis shall be conducted down to the item level sufficient to assure complete identification of system single point failure mode possibilities and the uncovering of any critical paths. The analysis shall also be covered in sufficient depth to reveal the most likely modes of failure, encompassing no less than 90% of these. In the performance of the FMEA, the effects of corrective maintenance actions shall be evaluated. In the event that performance of corrective or preventive maintenance, such as a replacement of a failed circuit card or assembly, affects an otherwise operable or functioning circuit, this effect shall be included in the analysis.

3.10.4 System Reliability.- The mean time between failures (MTBF) as defined in paragraph 3.10.6 shall be not less than 80,000 hours.

3.10.5 Equipment Reliability.- The mean time between failures (MTBF) as defined in paragraph 3.10.6 shall be not less than 8,000 hours.

3.10.6 Failures.- PCS failures fall into two categories, systems failures and equipment failures. The mean time between failures (MTBF) shall be defined by the following equation:

$$MTBF = \frac{\sum_{m} T_m}{m}$$ where, T_m = Total number of operating hours when mth failures occur. m = Number of failures (1,2,3 - -)

3.10.6.1 System Failures.- System failures shall be defined as those failures which cause the failure of the PCS to provide A/C power required by paragraph 3.8.

3.10.6.2 Equipment Failures.- Equipment failures shall be defined as any other than a system failure such as, "black box" assembly, card, or part failures whose impact upon the system may vary from a minor maintenance action to catastrophic. For example, the failure of a printed circuit card in the PCS which automatically causes a transfer to the bypass would be only classified as an equipment failure. However, the random or catastrophic failure of a component, assembly, or the bypass switch which causes an out of tolerance condition on the output or causes the cessation of all power transmission to the RML equipment, is both an equipment and system failure.

3.10.7 Failure Reporting, Analysis and Corrective Action Task.- The Contractor shall establish a closed loop system for reporting all failures. The level of equipment (e.g., circuit board, assembly, etc.) both manufactured and subcontracted items, for which the contractor proposes to maintain failure records, shall be delineated in the Reliability Program Plan. As a minimum, failures occurring from the time the design is frozen or witnessed tests begin shall be reported with analysis and results in a format suitable for automatic data processing. The Contractor shall analyze each failure to determine its cause (e.g., equipment manufacturer's design fault, part manufacturing defect, test error, etc.). Failure analysis shall include, to the extent necessary to determine the cause of failure, failed part analysis (including physical and electrical test, x-ray, dissection, and microscopic examination, as necessary) and design analysis (e.g., equipment application stress analysis, circuit tolerance or parts drift). Each analysis shall also include development of corrective action that may be required to prevent failure recurrence. Failure data reports, including analysis results, shall be maintained by the Contractor in a central file, to which the Government will have unlimited access and an individual report in a format suitable for automatic data processing shall be provided on at least a monthly basis. The Government QRO shall be notified of any failure within one (1) working day of its occurrence. The automatic data processing format shall be submitted for Government approval within 90 days after contract award.

3.10.8 Maintainability Provisions.-

3.10.8.1 Monitoring.- The PCSequipment shall include test points for input and

output wave form observation, measurement of critical voltages, sensors for hot spot temperatures, and other similar means to safely facilitate periodic monitoring of system operation.

3.10.8.2 Maintenance Power.- Control and logic shall be operable for servicing with the main circuit breakers, i.e., supply, output and main d.c. circuits open. A covered, polarized and identified male receptacle may be installed on the equipment for connection by portable cord to an adjacent 120 volt source. The receptacle shall be connected through a transfer switch to supply logic and control power during shutdown. Setting the switch to the maintenance mode shall inhibit the application of power to the main rectifier. A separate control circuit battery shall not be used.

3.10.8.3 Preventive Maintenance and Corrective Testing Provisions.- The Contractor shall provide circuitry test points and other means for testing the control circuitry with the system shut down or in bypass. Each test point shall be protected with a resistor or other means to prevent accidentally grounding and damage by test equipment leads. This shall include all closing and trip circuit breakers, contactors, logic, static switches, and solid state transfer switches. Printed circuit board extender cards, if required, shall be provided with each system by the Contractor.

3.10.8.4 Corrective Maintenance Time.- Mean time to repair (MTTR) is defined as the elapsed time in manhours starting with a system or equipment failure until the equipment is again available for service, including any checkout and warmup time required. The MTTR of the PCS shall not be greater than 1.5 manhours with a maximum repair time not greater than 8 manhours assuming that a spare for each part is available at the site. Not included in the MTTR are the primary input power and power wiring to and from the PCS.

3.10.8.5 Preventive Maintenance.- The Contractor shall develop a preventive maintenance plan and include it in the instruction book. Any preventive maintenance that will not allow the equipment to be returned to service and be put back on-line within 15 minutes shall be prohibited.

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- The Contractor shall provide and maintain a quality control program which fulfills the requirements of FAA-STD-013 Quality Control Programs. Unless otherwise specified in this specification or in the contract, all tests and inspections to determine compliance with the requirements of the contract specifications shall be made by the Contractor and shall be subject to Government inspection. The term "Government inspection," as used in this specification means that an FAA representative will witness the contractor's testing and inspection, and will carry out such visual and other inspection as deemed necessary to assure compliance with contract requirements. Tests shall be conducted at the Contractor's expense except that for

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4.2 Factory Tests.-

4.2.1 Classification of Tests.- Three classes of factory tests are required to be accomplished:

Design Qualification Tests
Type Tests
Production Tests

4.2.2 Test Procedure.- The Contractor shall submit to the Contracting Officer, at least 60 days in advance of the proposed date of the first tests, for FAA approval, a test plan showing the procedure for each of the three classes of tests, and sample copies of the data sheets to be used for recording test results. Each performance requirement shall be tested and appropriate results recorded.

4.2.3 Design Qualification Tests. - A design qualification test shall be performed on the first PCS of each size based on technical data submitted by the manufacturer.

4.2.4 Type Tests.- Type tests shall be performed on one system of each group of 20 systems for each size of PCS. The system shall be complete with all interconnections and shall include storage batteries as furnished for one of the installations of the size PCS being tested. Capability to operate at the maximum altitude shall be demonstrated by analytical means. The QRO shall select the system of a group to be type tested. For comparison purposes and Q.C. evaluation, the system selected for type tests shall not be delivered until the system from a subsequent group has passed these tests.

4.2.5 Production Tests.- Production tests shall be performed on the complete assembled system for each site and shall include the tests listed in paragraph 4.2.6. The reliability portion of production tests shall be conducted for at least 48 hours with no system failures.

4.2.6 Test Summary.- Tests in the following list shall be performed during the Design Qualification, Type and Production Tests as specified in the respective paragraphs of the specification. This list shall not relieve the Contractor of any other tests or performance required in other paragraphs of the specification. Type Tests and Production Tests, as required, may be conducted concurrently.

	Tests	Paragraph	Test Types* A	B	C
a.	Size	3.2.4	X	X	
b.	General Assembly	3.2.4	X	X	X

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a.	Size	3.2.4	X	X	
b.	General Assembly	3.2.4	X	X	X

	Tests	Paragraph	Test Types* A	B	C
x.	Automatic bypass	3.7.1	X	X	X
y.	Manual bypass	3.7.2	X	X	X
z.	Maintenance mode	3.7.3	X	X	X
aa.	Clearing distribution faults	3.8.2	X	X	
bb.	Voltage output regulation	3.8.3 & 3.8.7	X	X	X
cc.	Output wave form	3.8.4	X	X	
dd.	Efficiency	3.8.5	X	X	
ee.	Frequency regulation	3.8.6	X	X	X
ff.	Battery running time	3.9.2	X	X	
gg.	Reliability	3.10.1	X		X
hh.	High potential	4.2.8	X	X	
ii.	MTTR	4.2.7	X	X	

* Test Types - A - Design
B - Type
C - Production

4.2.7 Mean Time to Repair.- A maintainability demonstration shall be performed during type tests. Maintenance tasks to be performed shall be selected by the Contracting Officer's Representative(s) from a list supplied by the Contractor 30 days prior to the test.

4.2.8 High Potential.- All power components shall be given a high potential test while the equipment is at normal operating temperature. The test shall include the terminations of all internal wiring. The test voltage shall exceed 500 volts.

4.2.9 Field Verification Tests - PCS.- After completion of installation, the Contractor shall conduct tests to verify that the equipment performance has not been impaired during shipment and installation and that all remote and interconnecting wiring has been correctly installed. Test schedules shall be coordinated with Government personnel and shall be based on testing during off-peak hours, probably

	Tests	Paragraph	Test Types* A	B	C
x.	Automatic bypass	3.7.1	X	X	X
y.	Manual bypass	3.7.2	X	X	X
z.	Maintenance mode	3.7.3	X	X	X
aa.	Clearing distribution faults	3.8.2	X	X	
bb.	Voltage output regulation	3.8.3 & 3.8.7	X	X	X
cc.	Output wave form	3.8.4	X	X	
dd.	Efficiency	3.8.5	X	X	
ee.	Frequency regulation	3.8.6	X	X	X
ff.	Battery running time	3.9.2	X	X	
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e. If operating on commercial power, simulate power failure with automatic transfer to standby supply and then retransfer to commercial supply. If operating on standby supply, interrupt supply for 30 seconds and reclose supply.

f. Equipment shall be isolated by a simulated internal failure. The test shall be conducted with no loss of power to the critical load. After system is so tested, the system shall be restored to service.

g. Operate the inverter for a minimum of 30 minutes from battery source.

4.2.9.5 Tests with Facility Load.- After disconnection of the load bank, the facility load shall be transferred to the PCS. The following tests shall be performed:

a. Repeat test (e) and (f) of paragraph 4.2.9.4.

b. While operating on standby source, input frequency and voltage shall be increased to the maximum input condition for at least 15 minutes.

c. While operating on standby source, input frequency and voltage shall be adjusted to the minimum service condition for at least 15 minutes.

d. Adjust frequency to 60 Hz and transfer the critical load to bypass and then retransfer to the PCS.

e. The PCS shall be reconnected to the commercial supply and shall continue to serve the facility critical load for a minimum of 4 days without a failure.

f. Verify that EMI effects on RML do not exist at the first site and at one dual and one triple site.

4.2.9.6 High Potential Test.- Immediately after the equipment is installed all power components shall be given a high potential test at 80% of the factory test values. Insulation resistance of all power components shall also be measured and recorded.

4.2.10 Repair of Defects.- The Contractor shall, within 48 hours, replace or repair any components or material supplied under this contract which is disclosed to be defective during the tests. If failures occur in the tests at the several sites or at the factory, a failure analysis shall be performed and the Contractor shall initiate the necessary corrections at all sites within 15 days.

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